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GOLD REEF and NORTH FORK
HIGH ELEVATION RECLAMATION STUDY

by

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Chambers, and R. C. Sidle

FINAL REPORT for COLLECTION AGREEMENT
#INT 85-16
with Marathon Oil Company
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Final Report

Gold Reef and North Fork
High Elevation Reclamation Study.
(Collection Agreement INT-85-16)

Prepared by:

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Introduction

In the summer 1985 Marathon Oil Company drilled two wildcat exploration wells in the Absaroka Mountains in western Wyoming. These wells are east of Yellowstone National Park and in close proximity to the Absaroka wilderness in a political and ecologically sensitive area known as the greater Yellowstone Ecosystem. Both drill sites are located on the Shoshone National Forest which is headquartered in Cody, Wyoming.

The Gold Reef site is located on the Greybull Ranger District, Park County, Wyoming (Sec.34 T.47 N. R. 104 W.) at an elevation of 10,755 feet (3,278 meters). This is a semi-arid alpine ecosystem dominated by cushion plant communities. Soils are very shallow, coarse-textured and weakly developed. The climate is characterized by a cool short growing season of 60-90 days, low summer rainfall and almost constant wind.

The North Fork site is located on the Wapiti Ranger District, Park County, Wyoming (Sec.34 T.52 N. R. 106 W.) at an elevation of 7,643 feet (3,230 meters). The area is a typical inland Douglas-fir montane ecosystem. At ridgetop, where the drill site was located, the vegetation is dominated by grasses and forbs. Soils are shallow and poorly developed. The growing season is 90-120 days long characterized by dry and warm conditions. At both sites, the majority of the precipitation

occurs as snowfall.

These areas represent vitally important watersheds, wildlife habitat and rangeland for domestic livestock. They provide spectacular vistas and remote solitude for many recreationists and are located in one of the most politically sensitive areas in the United States. The Forest Service, Marathon Oil and the general public are concerned about potential damage as a result of drilling activities. As a result of these concerns, Marathon Oil entered into a collection agreement (INT-85-16) with the Intermountain Research Station. Under this agreement Station personnel made recommendations for and participated in the reclamation of these sites and evaluated the results of this reclamation. This final report presents the results of this combined effort.

Gold Reef Rehabilitation Methods

In August of 1986 the reclamation phase of the Gold Reef drill site and access road began with backfilling and contouring of all disturbed areas to as near the original contour as possible. This was necessary to prevent erosion, wind-scouring, and mass slumping and to improve visual impact. The previously stockpiled topsoil was then spread uniformly over the drill site and access road. Topsoil provides a more favorable seedbed with better nutrient and water holding capacity than subsurface materials.

Fertilizer was applied (using a small tractor drawn cyclone seeder) at the rate of 80 lbs of nitrogen per acre (89 kg/ha). Slow release commercial fertilizer, 16-16-16 (N-P₂O₅-K₂O), was used. This represents the following additions of N, P, and K respectively: 16, 8, and 12%. Fertilizer applications have been shown to enhance plant growth and development during reclamation on the Beartooth Plateau in Montana (Brown and Johnston 1976).

Following fertilizer application the drillpad and access road were tilled, on the contour, to a depth of 6-8 inches (15-20 cm) using a spring-tooth harrow. This procedure mixes the fertilizer into the topsoil, loosens the surface allowing better water penetration, and provides a more suitable medium for seeding.

Immediately following tillage, seed was applied with hand operated cyclone seeders at a rate of 45 pounds per acre (50 kg/ha) (Table 1). Care should be taken to account for prevailing wind, if any, which will effect seed distribution. Strong winds can blow the seed off of the area. In general, native species adapted to alpine or subalpine environments were seeded. The seed was purchased from seed suppliers specializing in native plant seed.

A set of weighted roller wheels was then drawn over the entire area, firming the seedbed and pressing the seed into the surface layer of soil. This step is essential to provide good contact between the soil and the seed. Initial germination and subsequent establishment will be reduced if this procedure is not

carried out.

The final step in this reclamation procedure consisted of spreading Curlex excelsior blankets over the entire area following the manufacturer's recommendations. A total of 600 blankets were used on the the drill site and access road. The blankets were held in place with 6 inch (15cm) soil staples. In these windy and harsh environments, mulch is essential for holding both seed and disturbed soil in place and to reduce the effects of frost heaving.

In June of 1987 the first of two plantings of containerized stock was installed (Table 2). These were planted in two groups. The first was on the reclaimed access road just inside the gate near ridge top (Appendix C,1A), and the second group was on the drill site (Appendix C,2A). In September 1987 a second planting was located adjacent to each of the spring planting areas. At each site and for both spring and fall plantings, 5 blocks were established. Within each block 10 rows were established at 18 inch intervals. Within each row, 15 individuals of one of the ten species was planted using an 18 inch spacing. Due to insufficient plants, only nine species were planted in the fall. In all a total of 2850 containerized forbs and grasses were planted.

Table 1. Gold Reef species composition of seeding mix and application rate.

Species	Pounds/Acre	Seeds/ft. ²
GRASSES		
Slender wheatgrass (<u>Agropyron trachycaulum</u>)	6.5	24
Mountain brome (<u>Bromus marginatus</u>)	6.5	13
Tufted hairgrass (<u>Deschampsia cespitosa</u>)	1.3	75
Idaho fescue (<u>Festuca idahoensis</u>)	6.5	75
Sheep fescue (<u>Festuca ovina</u>)	6.5	100
Alpine timothy (<u>Phleum alpinum</u>)	2	52
Alpine bluegrass (<u>Poa alpina</u>)	2	62
Canada bluegrass (<u>Poa canadensis</u>)	6.5	115
FORBS		
White yarrow (<u>Achillea millefolium</u>)	2	127
Engelmann aster (<u>Aster engelmannii</u>)	2	27
Blueleaf aster (<u>Aster glaucodes</u>)	2	25
Narrow-leaf paintbrush (<u>Castilleja linariaefolia</u>)	.8	90
SHRUBS		
Prairie sage (<u>Artemisia ludoviciana</u>)	1	103
Total.....	45.6	888

Table 2. List of species of containerized stock transplanted in the spring or fall of 1987 on the Gold Reef site.

Species	Spring	Fall
GRASSES		
Slender wheatgrass	x	x
Arizona fescue (<u>Festuca arizonica</u>)	x	x
Sheep fescue	x	x
Mountain brome	x	x
Tufted hairgrass	x	x
Alpine bluegrass	x	x
FORBS		
Blue leaf aster	x	x
White yarrow	x	x
Sweetvetch (<u>Hedysarum boreale</u>)	x	
SHRUBS		
Prairie sage	x	x

Gold Reef Assessment

In August 1988, two years after seeding, the Gold reef site was visited by scientists from the Intermountain Station to evaluate the reclamation effort. Cover, standing crop production, and relative species importance were determined. Assessment of the containerized planting area was not performed because it was impossible to distinguish the containerized plants from those that had established from seed.

Evaluation of the seeded drill site was accomplished by establishing two 30 meter transects near the center of the area (Appendix C,1B). Along each of the transects, 10 quadrats (0.25 m²) were randomly located (Chambers and Brown 1983). At each quadrat a cover photo was taken, a relative cover class was determined for each species and standing crop production was harvested by life form (grass, forb, or shrub).

The cover photo was taken using a tripod and camera positioned vertically over the center of the quadrat (Chambers and Brown 1983). The slide was then projected onto a grid containing 100 squares and the number of squares covered by vegetation, litter, rock, and bare ground determined. The data is summarized by percent cover for each of the categories.

The species cover classification was based on pre-determined cover class codes (Table 3). A coded value was assigned to each species that occurred within a quadrat based on the percent of

aerial cover it supplied to that quadrat. These data were subsequently analyzed by ranking these cover classes to determine relative importance of each species identified within all quadrats.

The harvested plant material from each quadrat was oven dried and weighted to determine production by quadrat and by life form. Since the Gold Reef site did not have different revegetation treatments imposed, these data were summarized using mean production to characterize the entire site.

Table 3. Cover classes and percentile groupings used to determine species relative importance.

Percent cover Grouping	Cover Class
< 1%	1
1-5%	2
6-10%	3
11-15%	4
16-25%	5
26-35% *	6
36-45% *	7
46-55% *	8
56-65% *	9
>65% *	10

* There were no values above 25% recorded.

Results

Average total production at the drill site was 977 lbs/acre (1095 kg/ha). Grass production was 944 lbs/acre (1058 kg/ha) and comprised over 95% of the total. In contrast, forb production was 33 lbs/acre (37 kg/ha) (Fig 1). Average aerial cover by cover class is presented in Figure 2. The vegetative component averaged was 36 percent, litter 56 percent, rock 2.5 percent, and bare soil was 5.5 percent.

The relative importance of each species was determined from a ranking of the average cover classes (Table 4). Slender wheatgrass and sheep fescue were co-dominant on the site, averaging about 9 percent aerial cover each. White yarrow, alpine bluegrass and Wheeler's bluegrass were next in importance, each with 2-3 percent cover. The remaining species comprised less than 1 percent each and could be considered rare. Several of the species encountered within the quadrats, including Wheeler's bluegrass, were native, unseeded colonizers.

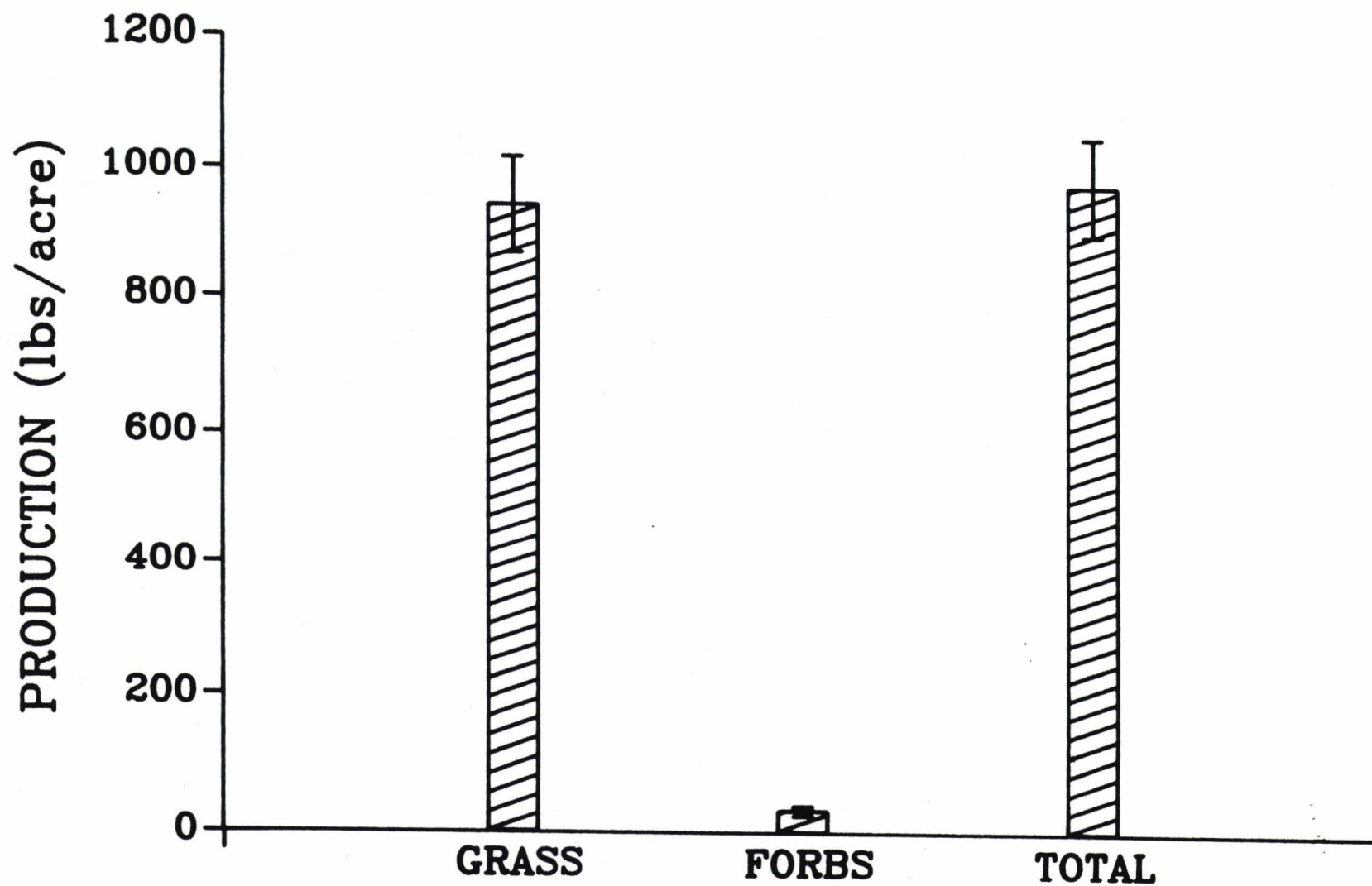


Fig.(1) Standing crop vegetation, Gold Reef site.
Values are means, error bars represent ± 1 SE.

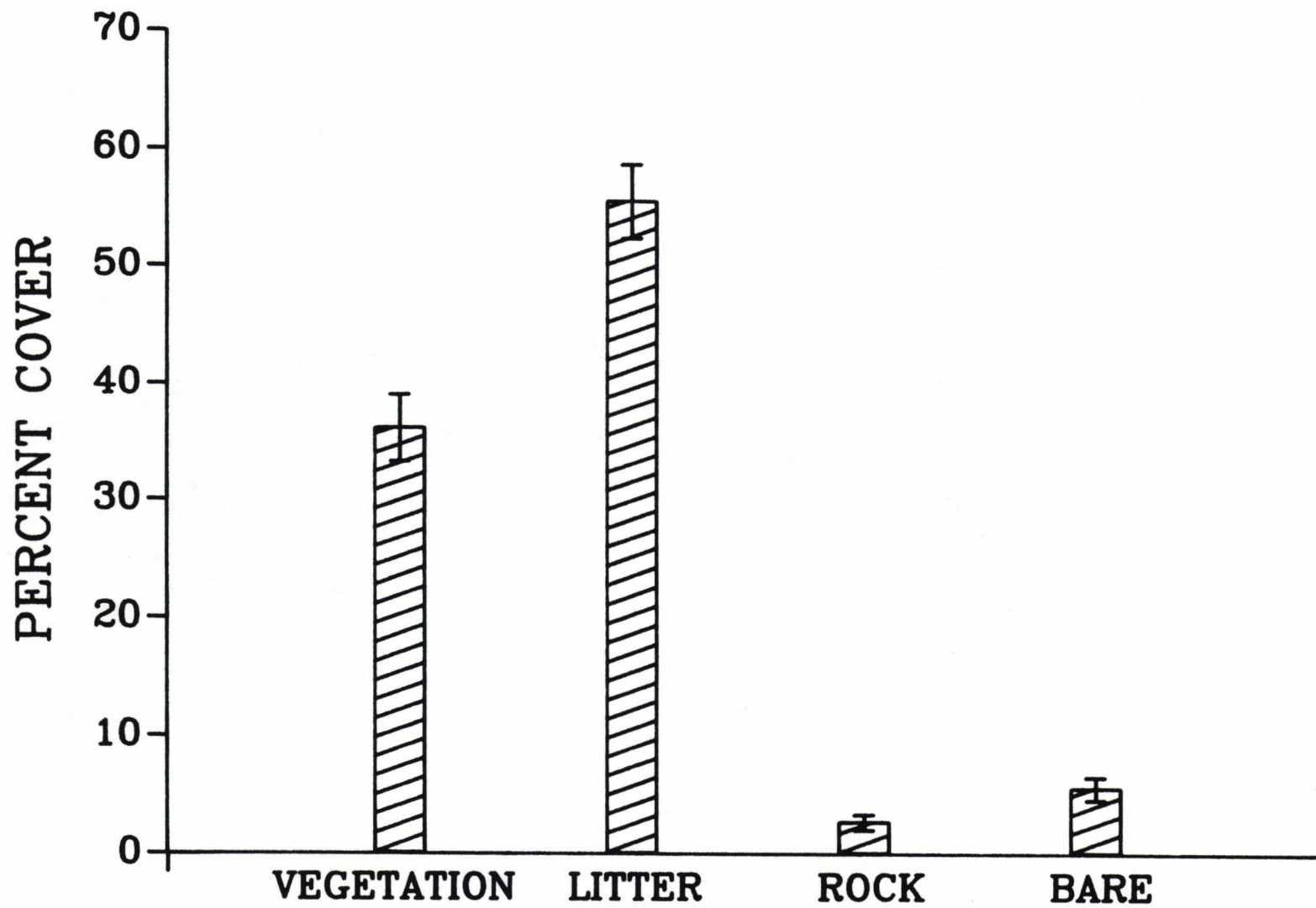


Fig.(2) Percent Cover at the Gold Reef Site.
Values are means.
Error bars represent ± 1 SE.

Table 4. Mean cover class, mean aerial cover and relative importance ranking of each of the species sampled on the Gold Reef site.

Species	Cover Class	Aerial Cover(%)	Rank
GRASSES			
Slender Wheatgrass (<u>Agropyron trachycaulum</u>)	2.65	9	13.5
Sheep Fescue (<u>Festuca ovina</u>)	2.65	9	13.5
Alpine Bluegrass (<u>Poa alpina</u>)	1.55	2.5	11.0
Wheeler's Bluegrass* (<u>Poa nervosa</u>)	1.50	2	10.0
FORBS			
White Yarrow (<u>Achillea millefolium</u>)	1.65	3	12.0
Alpine willow-weed* (<u>Epilobium alpinum</u>)	.1	<1	8.0
Sweet william* (<u>Phlox</u> spp.)	.1	<1	8.0
Chickweed* (<u>Cerastium arvense</u>)	.1	<1	8.0
Groundsel* (<u>Senecio</u> spp.)	.05	<1	3.5
Aster (<u>Aster</u> spp.)	.05	<1	3.5
Clover* (<u>Trifolium dasyphyllum</u>)	.05	<1	3.5
Whitlow-grass* (<u>Draba</u> spp.)	.05	<1	3.5
Ross avens* (<u>Geum rossii</u>)	.05	<1	3.5
SEDGES			
Carex* (<u>Carex</u> spp.)	.05	<1	3.5

* Denotes species that were not seeded on the area.

North Fork Rehabilitation Methods

The North Fork drill site was reclaimed in early October 1985. Since this area does not have an access road, all equipment and personnel involved in this effort were flown to the site by helicopter. The same basic techniques that were described in the Gold Reef methods section were used at the North Fork site. However, differences in site conditions and access to the site resulted in procedural changes.

The first difference is the site was less disturbed. Since the drill site was located at ridgetop, only limited site preparation was necessary to accommodate the drill rig. Soil disturbance was very limited and as a result only relatively minor reshaping was necessary when the drill rig was removed.

Equipment used in the actual reclamation had to be small enough to be transported by helicopter into the area. Four wheeled ATV's were used as small tractors, spike-toothed harrows were used in place of larger spring-toothed harrows, and specially designed sections of culvert that could be filled with sand were used in place of roller wheels.

Granular slow release commercial fertilizer (16-16-16) was applied at the rate of 50 lbs of nitrogen per acre (56 kg/ha) using hand operated cyclone seeders. The area was then harrowed using the spike-toothed harrow.

The seed mixture and application rate is shown in Table 5. Approximately one-third of the total amount of seed was applied

by hand-held cyclone seeders and then pressed into the seedbed with a horizontally ribbed culvert roller. The remaining 2/3 of the seed was then sown and the area rolled using a spiral ribbed culvert roller.

Six types of mulch treatments were applied to different sections of the seeded area. Inside the fenced area, four mulch treatments were applied: 1) no mulch, 2) straw covered with a layer of Conwed plastic netting and held in place with rocks, 3) two layers of firmly staked Conwed netting with straw "sandwiched" in between, and 4) jute netting over 1/4 inch of peat moss. Outside the fence three treatments were used: 1) no mulch, 2) Conwed plastic netting, and 3) jute netting. In the mulch treatments that included straw, the straw was uniformly spread by hand at an approximate rate of 1 ton per acre (2240 kg/ha). At this rate some soil could be seen through the mulch.

In the spring and fall of 1986, 3000 containerized plants were planted at the North Fork site (Table 6). Following the same procedure described in the Gold Reef methods section, one-half of the containerized stock was outplanted inside the fenced area on the no mulch treatment and the other half was planted outside and just north of the fence.

Table 5. North Fork seed mixture and application rates.

Species	Pounds/acre	Seeds/ft. ²
GRASSES		
Sheep fescue (<u>Festuca ovina</u>)	3.0	47
Bottlebrush squirreltail (<u>Sitanion hystrix</u>)	3.0	13
Indian ricegrass (<u>Oryzopsis hymenoides</u>)	1.3	4
Mountain brome (<u>Bromus marginatus</u>)	2.1	4
Bluebunch wheatgrass (<u>Pseudoragneria spicata</u>)	2.4	8
FORBS		
White yarrow (<u>Achillea millefolium</u>)	3.0	191
Wasatch penstemon (<u>Penstemon cyananthus</u>)	3.0	41
Eaton penstemon (<u>Penstemon eatonii</u>)	0.3	4
Rocky Mountain penstemon (<u>Penstemon strictus</u>)	1.2	17
Buckwheat (<u>Eriogonum umbellatum</u>)	3.0	24
Pacific aster (<u>Aster chilensis adscendens</u>)	3.0	184
Narrow-leaf paintbrush (<u>Castilleja linariaefolia</u>)	0.1	11
Arrowleaf balsamroot (<u>Balsamorhiza sagittata</u>)	2.3	3
Blue flax (<u>Linum lewisii</u>)	1.3	9
SHRUBS		
Fringed sage (<u>Artemisia frigida</u>)	0.7	73
TOTAL	29.7	633

Table 6. Containerized transplant stock planted on the North Fork site in 1986.

Species	Spring Planting	Fall Planting
GRASSES		
Bluebunch wheatgrass	x	x
Sheep fescue	x	x
Arizona fescue (<u>Festuca arizonica</u>)	x	x
Alpine fescue (<u>Poa alpina</u>)	x	x
Sandberg bluegrass (<u>Poa secunda</u>)	x	x
FORBS		
Blue flax	x	x
White yarrow	x	x
SHRUBS		
Fringed sage	x	x
Big sagebrush (<u>Artemisia tridentata</u>)	x	x

North Fork Assessment

In August of 1988, three years after seeding and two years after transplanting, this site was evaluated to determine percent vegetation cover, standing crop production, relative species importance, and mulch effects. It was impossible to distinguish between plants established from containerized stock and those established from seed; assessment of the outplanting blocks was not performed.

Evaluation of the North Fork site was accomplished by establishing five 30-meter transects (Appendix C,1C). Ten

quadrats (0.25 m^2) were randomly located within each transect. Four of the transects were located inside the fenced area; two on the no-mulch treatment and one on each of the straw mulch treatments. One transect was established outside and to the south of the fence. Initial observation of all of the mulch treatments indicated that they were similar in species composition and cover. The jute mulch area was too narrow to be effectively sampled.

The data collection and initial summarization techniques used for this site were identical to those described in the Gold Reef assessment section. In addition, the effects of straw mulch on standing crop production and cover percentages were evaluated using analysis of variance techniques. An arcsin transformation was performed on the percent cover data prior to analysis (Snedecor 1959). Differences in relative species importance between straw mulched and no-mulch plots was determined by Spearman's rank order correlation (Chambers and Brown 1983).

Results

Average total production for the no-mulch plots was 438 lbs/acre (490 kg/ha) and 625 lbs/acre (701 kg/ha) for the mulched plots (Fig 3). Production by forbs represents the largest component at this site. Shrubs represented only a small fraction of the total production. No significant difference in standing crop production was found between mulch and no mulch areas nor

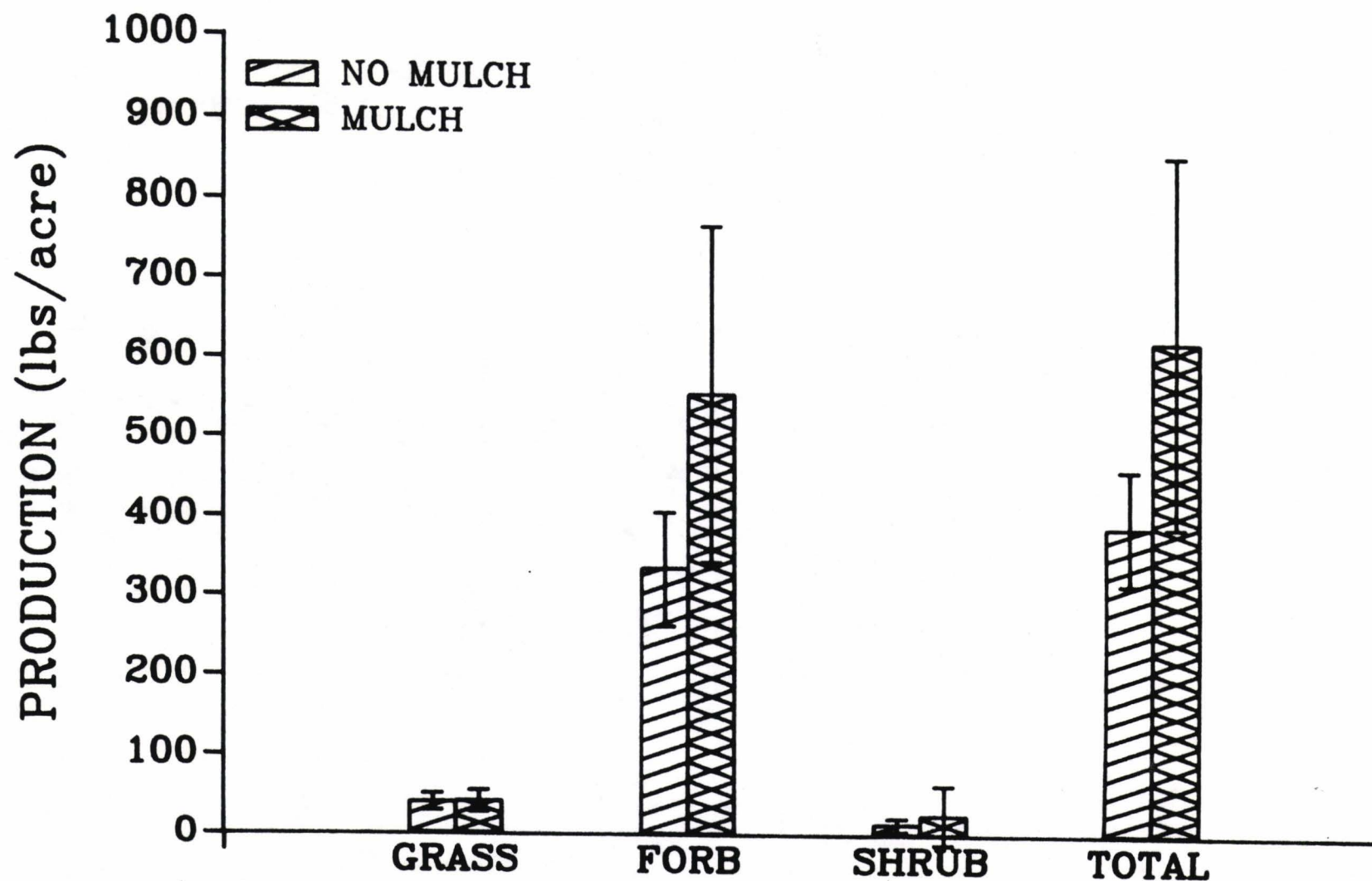


Fig.(3) Standing crop vegetation, North Fork site.
Values are means, error bars represent ± 1 SE.

did any of the vegetation components differ in total production. Mean aerial cover by cover category is presented in Figure 4. Both vegetation and litter had significantly higher percent cover on mulched than on no-mulch plots ($p < .01$). In contrast, percent rock and bare ground were higher on the no-mulch plots. There were no significant differences between treatments in cryptogam cover.

The relative importance of each species on the two different mulch treatments was determined by ranking the average cover classes by mulch treatment (Table 6). Spearman's rank correlation indicated that there is a significant difference (value 0.624) in relative species importance between mulch and no-mulch treatments. White yarrow was the dominant species on the North Fork site regardless of treatment, averaging 8 percent on the no-mulch area and 12 percent on the mulched sites. Sheep fescue, at 1.5 percent aerial cover, was next in importance. All other species averaged less than 1 percent cover on the no-mulch area. On the mulched sites penstemon was second in importance to white yarrow with 6 percent. Bluebunch wheatgrass and blue flax had fairly high importance at 3.5 and 3 percent cover, respectively. All other species comprised less than 1 percent aerial cover. Several species, such as spike-fescue and bitterbrush were not seeded on the area but were present as colonizers.

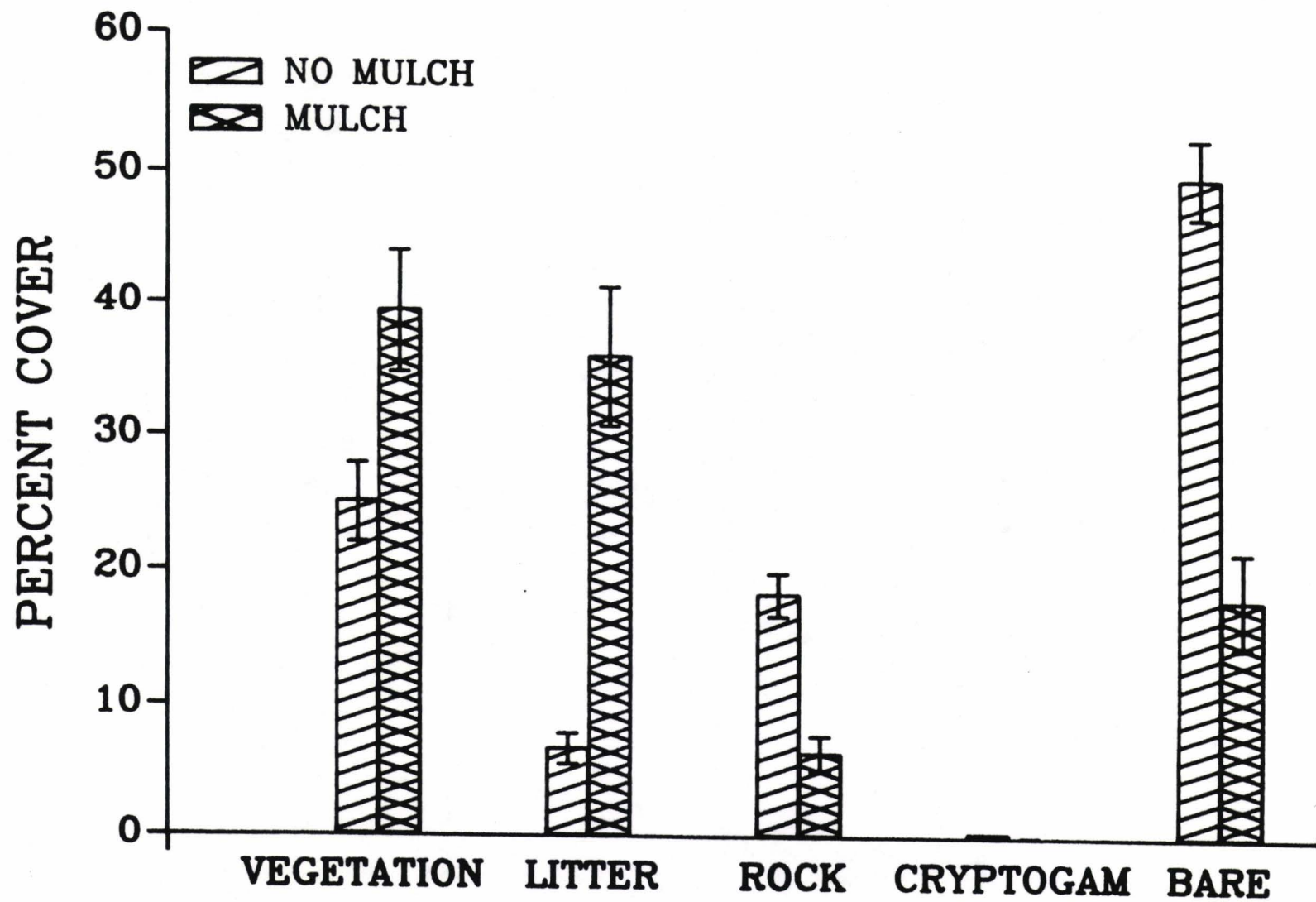


Fig.(4) Percent cover, North Fork site.
Values are means, error bars represent ± 1 SE.

Table 6. Mean cover class, mean aerial cover and relative importance ranking of each species by mulch treatment (NM= no-mulch, M= mulch) at the North Fork site.

Species	Cover Class		Percent Aerial Cover		Rank	
	(NM)	(M)	(NM)	(M)	(NM)	(M)
GRASSES						
Bluebunch wheatgrass (<u>Pseudoroegneria spicata</u>)	0.46	1.55	<1	3.5	10.0	11.0
Sheep fescue (<u>Festuca ovina</u>)	1.13	0.3	1.5	<1	12.0	7.5
Spike-fescue * (<u>Hesperochloa kingii</u>)	0.07	0.0	<1	<1	4.0	2.0
Bottlebrush squirreltail (<u>Sitanion hystrix</u>)	0.1	0.3	<1	<1	5.5	7.5
FORBS						
Buckwheat (<u>Eriogonum umbellatum</u>)	0.13	0.0	<1	<1	7.0	2.0
White yarrow (<u>Achillea millefolium</u>)	2.5	3.7	8.0	12.0	13.0	13.0
Blue flax (<u>Linum lewisii</u>)	0.8	1.4	<1	3.0	11.0	10.0
Penstemon (<u>Penstemon</u> spp.)	0.4	2.1	<1	6.0	9.0	12.0
Locoweed * (<u>Astragalus</u> spp.)	0.1	0.15	<1	<1	5.5	4.5
Narrow leaf paintbrush (<u>Castilleja linariaefolia</u>)	0.0	0.15	<1	<1	1.5	4.5
SHRUBS						
Fringed sage (<u>Artemisia frigida</u>)	0.27	0.25	<1	<1	8.0	6.0
Antelope bitterbrush * (<u>Purshia tridentata</u>)	0.03	0.0	<1	<1	3.0	2.0
OTHER						
Saprophyte *	0.0	0.6	<1	<1	1.5	9.0

* Denotes species not seeded to the area.

Discussion and Recommendations

Areas throughout the western United States are coming under increasing pressure by many different special interest groups. Mineral exploration in areas never before considered is becoming commonplace. The resulting disturbances to these natural areas from various causes has negative impacts on fragile ecosystems. Information concerning the rehabilitation of these lands in most cases lags far behind the rapidly increasing demands for resources from these areas. In many cases reclamation processes are site specific or at best applicable to limited areas. In contrast, certain reclamation techniques appear to have wide-spread applicability and promise when coupled with site specific information such as species selection, soil analysis, and fertilizer recommendations. These techniques are the same ones which were used to rehabilitate both the Gold Reef and North Fork sites. The following is a discussion of methods and techniques that may prove to be useful in such areas.

Prior to site disturbance:

1. Prior to any surface disturbance a vegetation survey should be undertaken to determine what native species occur on the site together with their relative importance in the ecosystem.
2. If this step was not completed prior to disturbance, the area immediately surrounding the disturbance should

be surveyed. This will provide information necessary for proper species selection and seed mix composition.

3. Following this survey, the "A" soil horizon to a depth of 6-8 inches (15-20 cm), should be stockpiled for use later in the reclamation process. In areas such as alpine tundra where there is no defined soil horizons, the top 6-8 inches (15-20cm) should be stockpiled whenever possible. This surface soil material is a reservoir of essential nutrients, native seed, and microbes which will facilitate the reclamation process. In addition, it will provide a better seedbed and increase the nutrient holding capacity.

Fertilizer requirements: The initial fertility and nutrient holding ability (cation exchange capacity) of the surface layer of topsoil should be determined from soil analysis. Sampling should be of sufficient intensity to adequately characterize the site. Sample intensity will depend on soil variability, but should include at least 4-6 independent samples per acre (10-15 per hectare) to a depth of 6-8 inches (15-20 cm). Fertilizer requirements and recommendations can then be established with the aid of the following considerations:

1. The species that are to be seeded. In general, native species have a lower nutrient requirement than do

introduced pasture grasses, and forbs and shrubs usually have lower requirements than grasses.

2. Include legumes in the seed mix. Nitrogen fixation by legumes will provide sufficient nitrogen for their needs and may provide some excess for other plants. Whiproot and parry clover are examples of legumes that should be considered in the seed mixture.
3. Incorporate organic matter into the soil profile. Organic matter can increase nutrient holding, moisture retention, and reduce compaction of soils. Additional nitrogen must be applied to compensate for nitrogen tied up during decomposition of organic matter which is high in carbon.
4. If indicated by soil analysis, apply lime or other appropriate amendments to compensate for soil pH needs at appropriate rates.
5. Several smaller applications of fertilizer at about two year intervals may be more beneficial than just one larger application during planting. Low nutrient holding capacity (cation exchange capacity) suggests that several applications of fertilizer would be more beneficial than a single one.

Site preparation: Following drilling, the site should be backfilled and contoured to as near the original contour as possible. The previously stockpiled topsoil should then be uniformly spread over the area. Fertilizer should be applied

either by hand, using cyclone seeders, or by tractor drawn equipment as the site permits. The area should then be tilled to a depth of 6-8 inches using a chisel plow or spring-toothed harrow. This is essential to mix the fertilizer into the soil and to provide a good seedbed. In some instances when soil compaction is a problem the area should initially be ripped to a depth of about 8 inches before the topsoil is spread. Such a condition could exist when relatively minor soil disturbance is necessary in order to establish a drill site (e.g. North Fork site). Soil compaction which results from associated drilling activities can impede water movement into the soil profile and restrict plant establishment and growth.

Seeding and Species Selection: Seeding should be done using hand operated cyclone seeders, or if possible, a Brillion seeder-packer. The Brillion seeder has the advantage that it will seed and press the seed into the surface of the soil all in one operation. The major disadvantage is that it does not do a good job of uniformly distributing some of the native seeds (those that have wings or parachute type attachments; or very small and large seeds in a mixture).

It is recommended that these "parachute" type seeds be spread by hand with the remainder seeded using the Brillion seeder-packer. Regardless of the seeding method it is recommended that all seed be mixed with rice hulls for more uniform distribution. If all the seeding is done by hand and/or with a cyclone seeder then it is necessary to press the seed firmly into

the soil using some ribbed roller device or the rollers on the Brillion seeder-packer.

Seeding rates should be calculated as the number of pure live seeds per square foot (Appendix A). When seeding rates are calculated on a pounds-per-acre basis small seeds will be seeded at a rate much higher than necessary, and larger seeds at much lower rates than needed. A seeding rate between 30 and 60 seeds per square foot is recommended. Heavier seeding rates are used on the harsher sites where wind will remove some of the seed or frost heaving mortality can occur. Seeding rates at both the North Fork and Gold Reef sites were much heavier than necessary to achieve acceptable results.

Species selection should be made using the previously mentioned vegetation survey to determine those species that are common to the area being reclaimed. Another good technique useful in species selection is to check old road cuts and other disturbances in the area for natural invasion. Commercial seed sources should be carefully screened using seed that was collected from as similar an area and elevation as possible. Although collection of seed by hand can be expensive, collection of adapted natives from adjacent disturbances may be the best and only source of seed available. Seed should be collected in the fall just at maturity. Appendix B contains a list of species that should be considered when seeding disturbed high altitude sites in the area covered by this report.

Fall seeding and planting is essential. Seeding of a site should be completed just before the first permanent snow. In the

Absaroka Range and similar areas, late August to late September is usually the best time.

Containerized stock: Outplanting containerized stock is useful in establishing vegetation on very harsh sites. If an area is rocky or other conditions such as slope steepness make regular revegetation techniques impossible or very difficult, outplanting can be a valuable tool. Outplanting provides a competitive edge which contributes to more successful establishment. It is a labor intensive and expensive method, thus limiting it's use to critical areas.

Mulching: There are many types of mulch and mulching equipment available for use when revegetating surface disturbances. Mulching has been used in many reclamation efforts for different purposes. In some applications it is used primarily for surface erosion control until the vegetation has become established. In other applications it is useful as a method to reduce effects of wind and to moderate the surface environment. In contrast, some reclamation efforts do not require any mulch at all. Selection of the proper mulch for an area requires a knowledge of why the mulch is being used. In many cases more than one type of mulch can be used with good success. In cases where surface erosion control is the primary concern, application of a straw mulch followed by crimping or hydromulching with wood fiber mulch give good results. When wind and surface insulation are the major concerns, possibly a better alternative is a commercially

available straw or excelsior blanket held firmly in place with soil staples. This alternative is expensive but more effective in reducing wind effects and temperature extremes at the surface. Additionally, the blanket keeps the mulch material evenly distributed on the soil surface. Most all mulches have the added benefits of reduction of surface evaporation and trapping of snowfall. This additional moisture can be very beneficial during seed germination and seedling establishment (Sidle and Brown, 1988).

In almost every case alpine reclamation processes will require some form of mulch. In many cases it will be the essential element which effects the success or failure of the revegetation process. Without mulch, wind can remove most seed from an area before it has a chance to germinate. Surface insulation will reduce mortality due to frost heaving and provide a better environment for seed germination. On the Gold Reef site it was evident that germination occurred under the excelsior blanket much earlier than where mulch was not present. This effectively increased the growing season and moisture available for successful establishment.

Results at both the North Fork and Gold Reef site indicate that vegetative establishment is possible and practical (Appendix C, 1D-2D). It should be noted that revegetation is just the first step in a long successional process to return the site to its original condition. In fact, these areas will visibly stand out from their surroundings for many years. However these differences can be partially minimized by careful planning, proper species

selection and mix composition, and proper application of reclamation techniques. The alternative will almost certainly result in failure.

APPENDIX A

Seeding rate calculations on a numbers of seeds per area basis.

A. Equal seeding rates for all species.

1. Area in square feet times Number of seeds per square foot equals total number of seeds required for total area.
2. Total number of seeds required for area divided by total number of species equals number of seeds per species.
3. The following calculation is for each species.
Number of seeds required for a species divided by number of PLS* per pound equals pounds needed for that species.

*Pure Live Seed per pound equals number of seeds per pound times the germination percent times purity.
(200,000 seeds per pound, 80% germination, and 95% purity equals 152,000 pure live seed in a pound of seed)

B. Unequal seeding rates for all species.

1. Total number of seeds required times percent composition of each species equals number of seeds for each species.

Examples are all calculated for a one acre area (43560 ft²) (.4 ha). and 200,000 seeds per pound.

a. Equal seed rates

1. 43560 square feet times 50 seeds per square foot equals 2,178,000.
2. 2,178,000 divided by 10 species equals 217,800 seeds per species.
3. 217,800 divided by 200,000 PLS per pound equals 1.1 pounds per acre per species.

b. Unequal seeding rates for species.

Species	percent composition	Number of seeds per species
1	10	217,800
2	10	217,800
3	20	435,600
4	30	653,400
5	30	653,000

APPENDIX B

Partial listing of High Altitude Reclamation Species.

<u>Species</u>	<u>Seeds per Pound</u>
GRASSES	
Slender Wheatgrass * <u>Agropyron trachycaulum</u>	159,000
Scribner Wheatgrass * <u>Agropyron scribneri</u>	293,000
Tufted hair-grass * <u>Deschampsia cespitosa</u>	2,500,000
Alpine timothy * <u>Phleum alpinum</u>	1,500,000
Alpine bluegrass * <u>Poa alpina</u>	1,050,000
Timberline blue-grass <u>Poa rupicola</u>	1,905,800
Skyline bluegrass <u>Poa epilis</u>	1,480,000
Spike trisetum * <u>Trisetum spicatum</u>	2,450,000
Sheep fescue * <u>Festuca ovina</u>	680,000
FORBS	
White yarrow * <u>Achillea millefolium</u>	2,770,000
Pale agoseris <u>Agoseris glauca</u>	318,300
Sandwort <u>Arenaria obtusiloba</u>	15,120,000
Starry cerastium <u>Cerastium arvense</u>	2,520,000

APPENDIX B (cont.)

<u>Species</u>	<u>Seeds per Pound</u>
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FORBS

Cerastium	#
<u>Cerastium beeringianum</u>	

Avens *	276,600
<u>Geum rossii</u>	

Silvery lupine	13,000
<u>Lupinus argenteus</u>	

Varileaf cinquefoil *	697,850
<u>Potentilla diversifolia</u>	

Groundsel	#
<u>Senecio fremontii</u>	

Sibbaldia spp. *	855,850
<u>Sibbaldia procumbens</u>	

false Solomon-seal	#
<u>Smelowskia calycina</u>	

Low goldenrod	1,468,000
<u>Solidago multiradiata</u>	

Whiproot clover	420,000
<u>Trifolium dasyphyllum</u>	

Parry clover	226,000
<u>Trifolium parryi</u>	

SHRUBS

Sagewort wormwood	1,527,300
<u>Artemisia campestris</u>	

Silver sage	1,417,500
<u>Artemisia scopulorum</u>	

* Denotes species successfully established from seed on alpine disturbed sites.

Information unavailable at this time.

The species listed here have broad ecological amplitudes and occur as frequent colonizers on alpine disturbances. Many have high reproductive rates and easily collectable seed. Seed mixtures will have to be adapted for the specific site and site conditions.

APPENDIX C

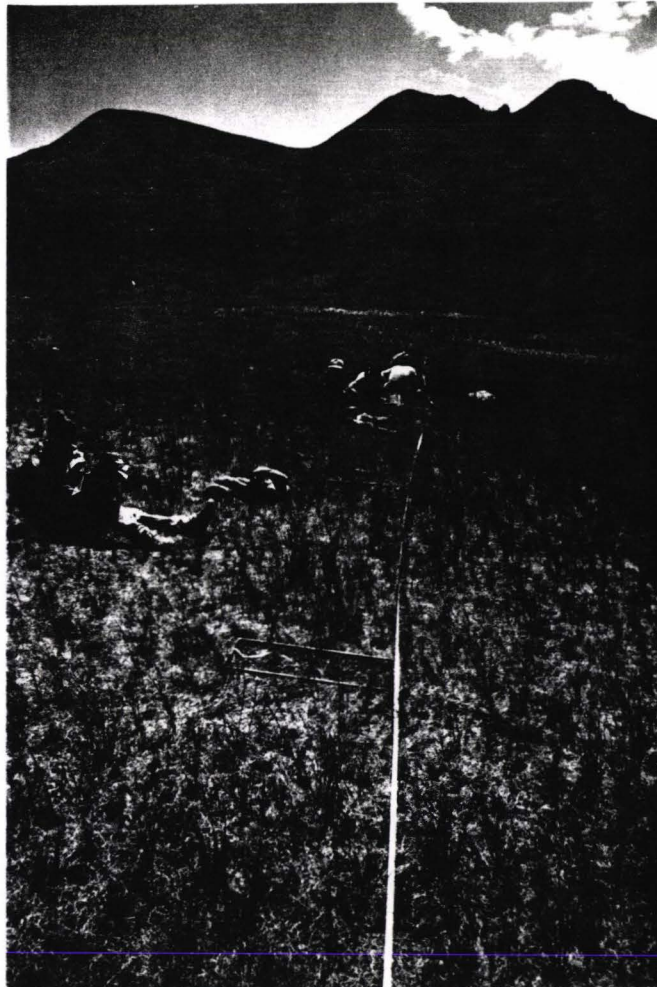


1A. Gold Reef; outplanting of containerized stock on the revegetated access road.



2A. Gold Reef; outplanting of containerized stock on the revegetated drill site.

APPENDIX C



1B. Gold Reef; vegetation sampling on the drill site.

APPENDIX C

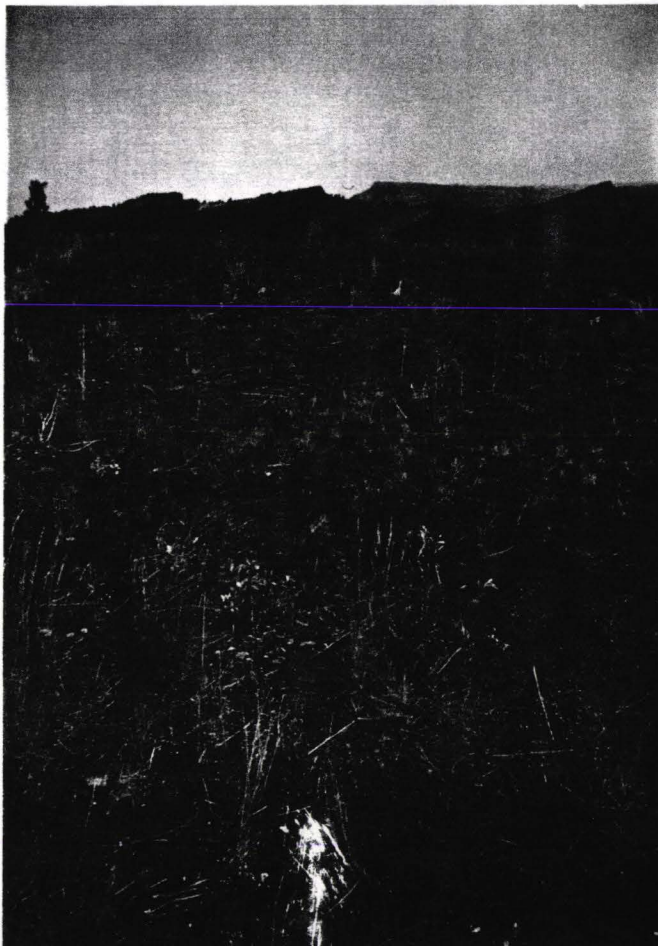


1C. North Fork; vegetation sampling

APPENDIX C



1D. Gold Reef: vegetation in August
of 1988.



2D. North Fork:
vegetation in
August of 1988.

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